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Influence of the Tractor on Use of Horses

THE FIRST QUESTIONS that the prospective tractor owner asks are:

For what operations can I use the tractor?

In what operations will it displace horses in whole or in part?

How many horses will it displace on my farm?

This bulletin is designed to help the farmer answer these questions for himself. It is based on the personal experience of 191 tractor owners in seven Corn-Belt States. It shows that on these farms the number of horses kept was two or three per farm less after the purchase of tractors, that the average size of the farms was 22 acres more, and that the horses left on the farms did 75 per cent of the tractive work, while the tractors did 25 per cent. All the reports emphasize the fact that the great advantage of the tractor lies in its ability to save time at critical seasons when time is precious and the success or failure of an entire crop hangs on the speed with which it is handled.

Office of the Secretary
Contribution from the Office of Farm Management
H. C. TAYLOR, Chief
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INFLUENCE OF THE TRACTOR ON USE OF HORSES.

(CORN BELT—191 FARMS.)

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CONTENTS.

GENERAL CONDITIONS.

TRACTOR INVESTIGATIONS, with special reference to the influence of the tractor on horse labor, were made in the summer and fall of 1918 on 191 Corn-Belt farms. The operators of these farms, all tractor owners, were visited by a representative of the United States Department of Agriculture, and detailed information on all farm operations was gathered. The inquiry covered a full year's work, so that the part played by the tractor might be noted in all its relations. The aim of this bulletin is to present the more important facts brought out by the reports of these farmers.

The investigation was carried on in Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska. In each of these States localities were visited in which a large number of tractors were in operation. The information obtained and here presented, while perhaps strictly and fully applicable only to the farms visited, may be taken as a general guide as to the results which might be obtained in using a tractor on any Corn-Belt farm of like type and organization. Of course the statements here made and conclusions drawn are not advanced as being final, but simply as additions to the available information regarding farm tractors.

NOTE.—Acknowledgment is due to Mr. H. R. Tolley, of the Office of Farm Management, for valuable assistance in the preparation of this bulletin.

In figure 1 the seven Corn-Belt States are shown. The black area in each State shows the section where the information was obtained. The same number of reports was obtained from each State.

To obtain results which would give as near a representative average as possible, an effort was made to get reports covering tractor operations under as many different conditions as possible, and hence the conditions represented range from adverse to ideal. The farms visited ranged from flat to hilly. The soils varied from the heaviest gumbo through all the various loams to light, drifting, sandy soils. Some of the gumbo soils now under cultivation on these farms were

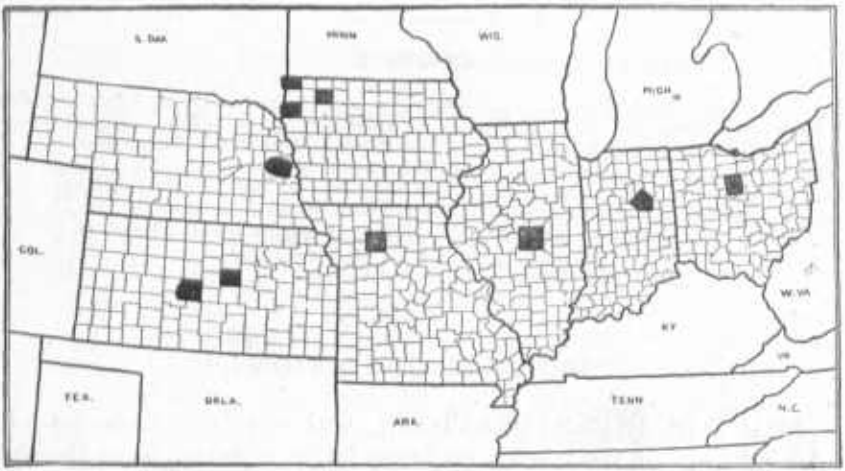

FIG. 1.—Corn-Belt States, showing areas where data were obtained.

formerly unproductive, owing to the inability of horses to plow these soils. With the introduction of the tractor, this land has come under cultivation and is now yielding big returns. It was found that tractors were operated successfully in what would be termed unfavorable as well as favorable seasons, which would tend to show their general adaptability.

While the section covered is roughly called the Corn Belt, farm practices are not uniform throughout the region. In most parts of the eastern Corn-Belt States commercial fertilizers and lime are used, these being applied by horse-pulled distributors. In preparing the land for crops all the ground may be plowed, or the small grain may be seeded on the previous year's corn ground by disking or harrowing, without plowing. The latter practice reduces work for horses or tractor in the busy season. Whether most of the plowing is done in the fall or only a small part, and the rest in the spring, depends largely on location. Where fall and spring plowing are done in about equal amounts on individual farms, the tractor is used more in

the fall than in the spring, and horses vice versa. It was found that when all the reports obtained were grouped together only five more operators plowed in the fall than in the spring, but the number of acres plowed in the fall averaged 23.7 more per farm. The number of men using horses as an auxiliary source of power was practically the same in each case. The number of acres plowed by horses averaged 18.6 more per farm for the fall than for the spring.

Many farms have woodlands, and as these are cleared the tractor is used for sawing the wood for market, thus increasing the days of belt operation. The scarcity of labor in 1918 hampered the gathering of crops, and in the States on the eastern edge of the Corn Belt the tractor was used to a considerable extent in the hay field, to the exclusion of horses.

As corn is the principal crop in this region, the effect of the tractor on horse labor will be more noticeable in the case of this crop than that of any other crop grown, the average acreage of corn per farm of those visited being 83.5 acres, which is 32 per cent of the tillable area of these farms. The remaining crops grown on these farms, in order of crop acreage, are: Wheat, hay, oats, barley, and rye.

In this bulletin only the physical relationship of tractor power to horse power has been considered, and no attempt is made to compare the relative costs of doing work by these sources of power. The number of horses displaced on these farms is also shown, but no inference has been drawn as to whether the work is being done more cheaply as a result of the change.

SUMMARY OF RESULTS.

Briefly summarized, these are the principal facts brought out or emphasized by this study:

1. The number of horses disposed of on 141 farms averaging 346½ acres, on which tractors had been used for a year or over, was 2½ per farm.

2. The average number of tillable acres per horse increased from 26½ to 38½ after the purchase of the tractor.

3. Nine operators out of 191 displaced horses entirely on plowing, disking, and harrowing.

4. Only 16 operators allowed their horses to stand idle while the tractor was in use.

5. The number of horses displaced by the tractors on these farms was governed by the number it was necessary to retain for corn cultivation and other work current at the same time, which the tractor could not do.

6. The horses remaining on these farms are doing about 75 per cent of the tractive work and tractors the remainder.

7. The tractor was used for an average of 29 ten-hour days per year on the home farm. No record of the amount of custom work done was obtained.

8. A three-plow tractor on these farms does the work of 8½ horses in plowing, disking, harrowing, and harvesting.

9. After purchasing the tractor, the average size of the farms was increased by 22 acres, or 6⅓ per cent.

10. The principal advantage of a tractor is its ability to do heavy work in a shorter time than it can be done with horses.

SIZE OF FARM.

The farms visited in this study varied considerably in size, the smallest being of 80 acres and the largest of 1,640 acres. Only one tractor was used on each of these two farms, while some of those between these limits operated two or even three machines. As a rule, the smaller farms were found in the eastern section of the Corn Belt.

The average size of all the farms visited was 323.8 acres, or, in round numbers, a half section. No definite statement can be made from the figures obtained as to the smallest farm on which a tractor is profitable. This will have to be left entirely to the individual and his particular needs and desires. While it would appear from available reports that a tractor will not prove a profitable investment on a farm of 80 acres, in some cases the end to be accomplished may justify the expense on such a farm.

The 141 farms of various sizes upon which tractors had been in operation for a year or more were arranged into seven groups according to acreage. The size of each group and the number of farms are given in Table I, and it will be noted that the greater number of farms fall in the groups ranging from 141 to 220 acres and from 221 to 300.

TABLE I.—*Number and size of farms.*

Size of farm.	Number.	Size of farm.	Number.
Under 141 acres	10	381 to 540 acres	18
141 to 220 acres	36	541 to 700 acres	16
221 to 300 acres	35	701 acres and over	10
301 to 380 acres	16	Total	141

The size of the farm, for the present at least, has a close relationship to age of the tractor, for it is found that on the farms of 540 acres and under the tractors in service have been used an average of about two years, while on the farms of 541 acres and over the average age is three and three-quarters years. This is due to the fact that the large tractors, which were the first to be manufactured, as a rule, were purchased by owners of large farms, while the small farm, which as a general thing could not economically use a large tractor, waited until the advent of the small machine, which is of comparatively recent manufacture. The size of the tractor and farm is shown in Table II (see p. 8). It will be seen that but for the few exceptional cases where small tractors were on large farms and vice versa, the difference in age would be still more marked.

An important trend is indicated by the effect of the tractor on the size of the farm, which was often increased after the introduction of the tractor.[1]

Of a total of 55 farmers who reported a change in acreage, 46, or 83½ per cent, reported an increase, averaging approximately 110 acres each. The remaining nine farmers, or 16½ per cent, reported a decrease, averaging 154 acres. These men moved to smaller farms and were not able to rent more land. It is not always possible to increase the size of farm at will, since additional land is not always available in the immediate vicinity.

Of the number using tractors who reported their acreage unchanged, several said that they would have increased the size of their farm, but because of lack of help found it impossible to do so. In a large number of cases where the tractor was purchased for use in 1918, the purchase was made so that the farm work could be done; otherwise some of the land would have been idle. The labor saved in these cases is reported as amounting to from one to three men, depending on the size of the farm. Another saving by the tractor, then, is that of hired help, since it enables one man to handle an increased acreage.

SIZE OF TRACTOR.

Five large tractors were found ranging in size from 8- to 12-plow and in age from 8 to 12 years. All other tractors ranged in size from 2- to 6-plow. Just as the acreage of the farms from which reports were obtained increases according to the location from east to west, so also does the size of tractors increase according to location from east to west. Most of the tractors found ranged in size from 2- to 5-plow.

[1] See also Farmers' Bulletin 963, p. 7.

TABLE II.—*Size of farms visited and size of tractors on each.*

Number of bottoms.	Number of acres, inclusive.							Total number of tractors.
	Under 141.	141 to 220.	221 to 300.	301 to 380.	381 to 540.	541 to 700.	701 and over.	
	Number of tractors.							
2	14	30	17	1	7	.....	.....	69
3	6	16	26	15	12	10	5	90
4	1	1	3	2	2	3	3	15
5 and over	.....	1	1	2	1	8	4	17
Total	21	48	47	20	22	21	12	191

It will be seen (Table II) that the 3-plow machines considerably outnumber any of the others. This size of tractor seems to be the most popular among farmers in general and is the same size as was recommended by farmers in Illinois, as shown by an earlier investigation.[1]

When it was realized that the large tractor was not suitable for the ordinary Corn-Belt farm, the tendency was toward the small tractor pulling two plows, the result being that many farmers went to the other extreme and bought machines too small for their needs. The 5-plow tractors and larger average 5½ years old, the 4-plow 2¾ years old, the 2-plow 2 years old, and the 3-plow slightly less than 2 years old. This indicates that the latest size to be tried out extensively is the 3-plow machine.

Judging by the figures in Table II, there does not seem to be as yet a fixed opinion in the minds of these men as to the number of acres on which machines of given sizes are most profitably operated. It seems that the operators who are using 2-plow machines on farms of 301 to 540 acres, 4-plow machines on farms of 220 acres or under, and 5-plow and over on farms of 300 acres or under, would have done well to have investigated the experiences of other men before buying their tractors.

The average size of the farms upon which the 2-bottom tractor was used is 224 acres; 3-bottom, 334 acres; 4-bottom, 493 acres; and 5-bottom and over, 623 acres.

AGE OF TRACTOR.

As has already been said, the small tractor has been developed since the large machine, and it is now the tendency for the smaller tractors to outnumber the large machines, which, however, are still manufactured to a considerable extent. The tractors in question, when arranged according to age, show more machines of from one

[1] Farmers' Bulletin 963, page 7.

to three years old than of all other ages combined. When the machines one year old or over are arranged according to age, it is found that there are 56 from one to two years, 33 from two to three years, 34 from three to four years, 10 from four to five years, and 11 which were five years old and over. The machines under one year old numbered 47. While there are many more tractors in the one- to three-year groups than in all the remaining groups, it must be

FIG. 2.—One man with tractor and double-disk harrow (upper) doing the work of two men and two 4-mule teams with two single-disk harrows (lower).

remembered that the small numbers in the older group are due to the wearing out and discarding of many of the older machines and the purchase of new models.

Age is closely related to size of tractor, for, as a general thing, the old tractors are the large tractors of five plows or over, while the new machines are the small tractors of two to four plows. The 56

tractors from one to two years old, the 33 from two to three years, and the 34 from three to four years averaged in size 2¾ plows, while the 10 which were four to five years averaged 3¾ plows, and those five years old and over, 6½ plows. Opinion, after some years wavering, seems to be settling on the 3-plow tractor as the logical machine for most farms, as it will be noticed from Table II that this size outnumbers all others.

TRACTOR OPERATIONS.

The farmer's main object in buying a tractor is to be able to do the heavy field work more quickly and easily than it can be done with horses, so that he can farm a greater acreage or handle his present acreage in a more efficient manner. It is noticeable that the men who have owned a machine for one year or less use it, as a rule, only for plowing and a little belt work. However, there are exceptions to this rule, for some who have owned machines less than a year use them on every operation possible, even outdoing the older operators on the total number of different uses. As a rule, however, the longer a machine is owned and the more experienced the operator becomes the more operations he finds the tractor can be used for. Here again, though not every use made of a tractor is a profitable one for all farms, each may perhaps be justified in individual instances.

In any section it will be found that plowing is the principal operation for which the tractor is used, and that, on the average, the days it is used in draw-bar work will outnumber those devoted to belt work. In gathering reports from tractor users it was the aim to list all of the different operations for which the tractor was used on each farm. The list of operations obtained brought to light some uses that were of a rather unusual nature. To both the experienced and the inexperienced operator a list of all these operations, both common and uncommon, should be of interest as suggestive of the possibilities of the tractor. (See fig. 3.) The largest number of different operations carried on by any one individual was 11, while several others used their tractors for 10 distinct operations. For all farms the operations averaged about 5, which seems low, considering what individual farmers have done.

List of operations in which tractor was used on 191 Corn-Belt farms follows:

DRAWBAR.

Plowing.
Listing.
Disking and spading.
Harrowing and planking.
Rolling and culti-packing.
Seeding grain.
Cultivating corn.
Loading hay.
Pulling hay fork.
Grain harvesting.
Corn picker and binder.
Manure spreader.
Moving buildings.
Road grading and dragging.
Building dike.
Clearing land.
Stretching fence.

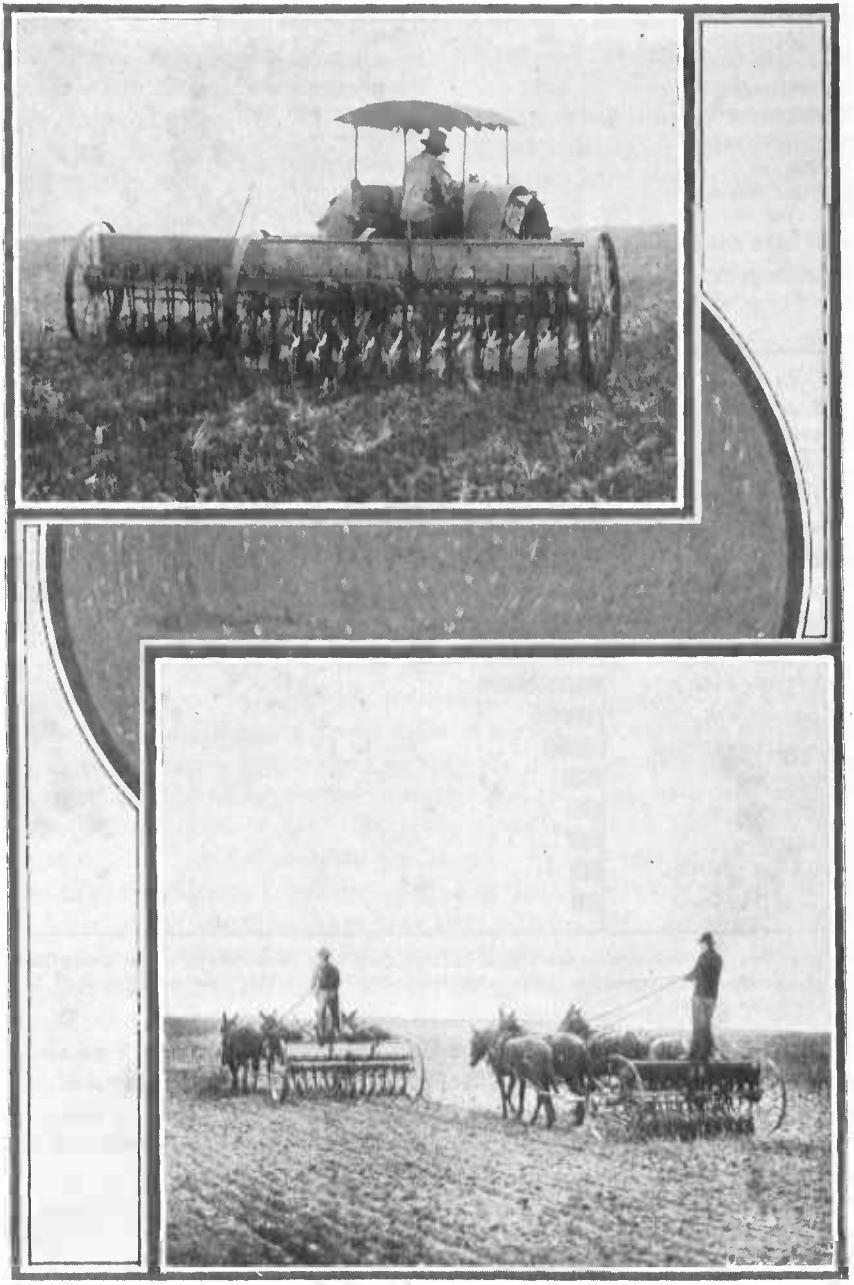

FIG. 3.—One man with tractor drilling wheat (upper) doing the work of two men and two 4-mule teams (lower).

BELT WORK.

Thrashing grain.
Hulling clover.
Elevating grain.
Shredding corn.
Shelling corn.
Ensilage cutter.
Baling hay.
Sawing wood.
Saw mill.
Cider mill.
Feed grinding.
Pumping water.
Pumping for irrigation.
Concrete mixer.
Tomato canning factory.

While many of the above operations are exceptional, they nevertheless show the large possibilities of the tractor as a source of power for farm work, as well as its adaptability to a large variety of uses.

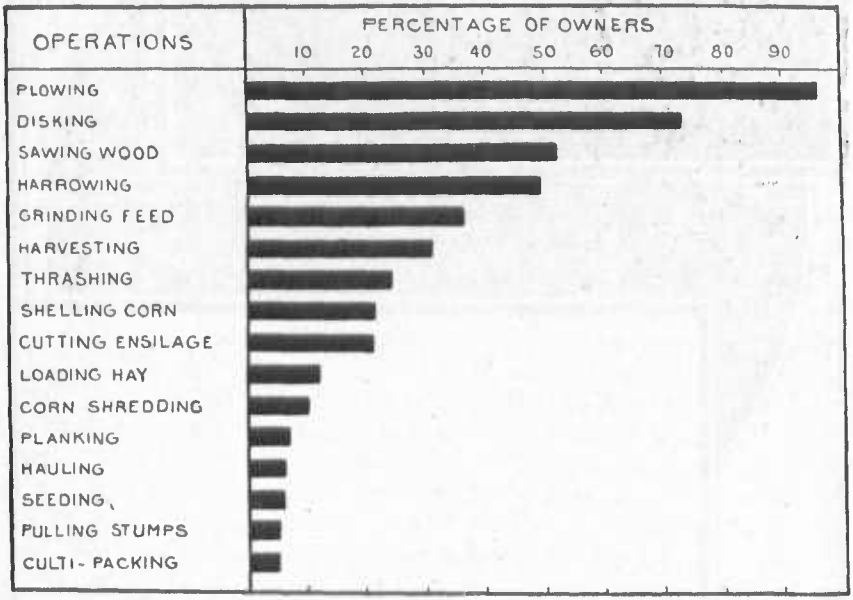

FIG. 4.—Various operations for which 191 tractors were used, showing the percentage of users for each operation. No operation carried on by less than 5 per cent of the operators is listed.

The principal operations on which tractors are used are small in number when compared with the entire list as given. Figure 4 shows the major operations for which 191 tractors were used and the percentage of owners using them in each case. Operations which were not performed by at least 10 tractors are not included.

As is natural to suppose, plowing leads all operations from the standpoint of number of users, with 96 per cent. The 4 per cent who did not use their tractors for plowing owned old machines which they had found too heavy for their conditions. It may be surprising to note that over 50 per cent used their tractors as a source of power for sawing wood, in many cases saving the expense of the purchase of a stationary engine to do this work.

One other operation may be cited because of its unusual character hitherto, that of loading hay. Twelve per cent of the operators used their machines for pulling the hay wagon and loader. Labor shortage was principally responsible for the size of this group, for the work was done with one man fewer than when horses were used. Each of the farmers seemed to be pleased with the results obtained and stated that it was his intention to continue the operation another year. All of these operators used the tractor with one wagon and loader. If two wagons and two loaders were arranged so that they could be pulled at the same time, as is frequently done, it would result in a still greater saving of time and labor.

While there is a great deal of objection on the part of some to using the tractor on prepared ground, especially after disking, it will be seen that nearly 50 per cent of the owners used the tractor for harrowing. In the case of planking and cultipacking, the number dropped to less than 10 per cent, but this is due to the fact that few perform these operations at all.

EXCLUSIVE AND COMBINED USES OF TRACTOR AND HORSES.

On very few farms are any operations now performed entirely with the tractor for which horses were formerly used exclusively. As shown in figure 4, most of the owners use their machines for plowing. Plowing should then no doubt show to a greater extent the number of operators using a tractor exclusively for any one operation. It was found that the older tractors shared the plowing with horses more than the newer machines. With the older machines, too, horses were used more often to finish up the fields. This is due to the fact that the newer machines are more easily handled in plowing out corners.

Nine operators stated that now they never have a horse in the field for plowing or disking and harrowing, while others used the tractor exclusively in the fall and horses to a great extent in the spring, because of moisture conditions. In some localities visited it was impossible to plow with horses in the fall of 1918 owing to unusually dry weather, which left the soil so hard that it was impossible to keep a horse-drawn plow in the ground. Under this condition the tractor user was working every day preparing the ground for winter wheat, while the farmer depending on horse labor was compelled to wait for rain to soften the soil. Such an interval of forced waiting may entail crop failure for the following season.

In considering the exclusive or combined use of the tractor and horses on farm operations, only those operations in which the two sources of power compete in a major way are considered. These are spring and fall plowing, disking, harrowing, and harvesting.

TABLE III.—*Number of operators who use tractors exclusively, horses exclusively, or both, for spring and fall plowing.*

Size of farm.	Number of farms.	Spring plowing.			Fall plowing.		
		Tractor only.	Tractors and horses.	Horses only.	Tractor only.	Tractors and horses.	Horses only.
Under 141 acres	10	8	1	.....	4	1	3
141–220	36	14	12	2	16	9	5
221–300	35	13	19	1	16	13	3
301–380	16	7	6	1	9	4	2
381–540	18	9	6	1	8	8	1
541–700	16	2	5	3	10	5	2
701 and over	10	1	4	.....	3	6	1
Total	141	54	53	8	66	46	17

To make possible a comparison of practices in these operations, 141 farms were arranged into 7 groups according to acreage, and classified according to utilization of tractor power and horsepower. (See Table III for plowing and Table IV for harvesting.) The weight of the machine will govern to a considerable extent its use in disking and harrowing, and it will be noted that on the larger farms, where as a general thing the tractors were large machines, tractors were not so generally used for this work as on the smaller farms with the lighter machines.

TABLE IV.—*Number of operators who use tractors exclusively, horses exclusively, or both, for harvesting.*

Size of farm.	Number of farms.	Harvesting.		
		Tractors only.	Tractors and horses.	Horses only.
Under 141 acres	10	2	1	6
141–220	36	7	3	26
221–300	35	8	2	24
301–380	16	4	3	9
381–540	18	3	3	12
541–700	16	3	4	9
701 and over	10	.....	.....	10
Total	141	27	16	96

These tables show that in each case the percentage of operators who use their tractor exclusively drops off rather gradually as the farms get larger, which is attributable to the inability of the tractor to do all of the work on these larger farms. In harvesting it is seen that on the very large farms the work is done entirely with horses. In the case of three operators this was due to the unwieldly size of

the tractor, and in those of the remaining seven to an abundance of horsepower which otherwise would have been idle (fewer horses being displaced on these large farms than on any other group). While the use of a tractor saves horses in harvesting, it does not save in man power. With horses one man can handle the outfit, while with the tractor two are usually required.

Table V shows the same group of farms as Tables III and IV, classified according to practice in disking and harrowing. It will be seen that the number of exclusive tractor users is considerably smaller than for any of the other operations. This decrease in the exclusive use is mainly due to fear of packing soft ground, and to unfavorable moisture conditions in the spring.

TABLE V.—*Number of operators who use tractors exclusively, horses exclusively, or both, for disking and harrowing.*

Size of farm.	Number of farms.	Disking and harrowing.		
		Tractor only.	Tractors and horses.	Horses only.
Less than 141 acres	10	2	8	.....
141–220	36	5	21	10
221–300	35	3	25	7
301–380	16	2	9	5
381–540	18	1	14	3
541–700	16	1	9	6
701 and over	10	.....	6	4
Total	141	14	92	35

One hundred and six farmers used their tractors for disking and harrowing, while for fall and spring plowing and harvesting the numbers are 112, 107, and 43, respectively. The average number of days' work spent on each of these operations in the order that they are given above is 6.9, 8.9, 7.2, and 3.9. At the same time on these farms 20.2, 8.4, 6.3, and 5.5 horse days also were required for the respective operations. These figures would tend to show that where the conditions are at all favorable the operator will use the tractor as much as possible.

It will be of interest to note further that, of the operators who used only tractors for disking and harrowing, the majority used two-plow machines, the remaining few using three-plow. The operators who used their tractor in conjunction with their horses had machines which averaged three plows, while those who used only horses for these operations, owned tractors which averaged four plows. Size of tractor would, therefore, seem to be significant if it alone is to be used for disking and harrowing, or if its use in conjunction

with horses, which seems to be the most common practice on these farms, is contemplated. The use of the tractor with horses is not only the most common practice, but in most cases the most practical, as soil conditions in the spring are not always ideal for use of the machine.

ANNUAL USE OF TRACTOR AND HORSES.

The days in a year that any machine is used depend upon a combination of conditions. If the tractor is used as the source of power for belt work, instead of a stationary engine, the total number of working days will be increased considerably. Again, seasonal and weather conditions will influence the days used annually.

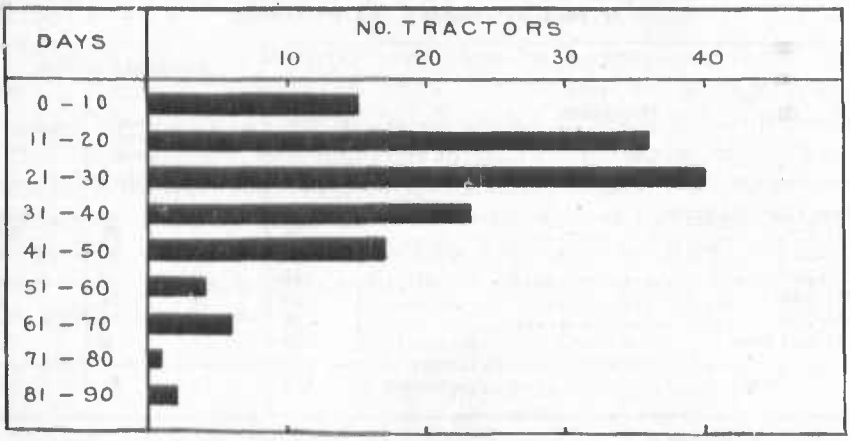

FIG. 5.—Number of days 144 tractors one year old, or more, were used annually.

In determining the number of days that the tractor was used annually, an effort was made to ascertain the number of full days' work. It was noted that in giving figures on number of days' work operators often called fractions of days whole days. For example, where feed was ground two days each week during the winter months, the number of days' work done was given as two days a week, when in reality the tractor was run only two hours each day, or less than one-half a day per week. It was necessary, therefore, to reduce all working time to a 10-hour day basis, as was the case in arriving at the time a horse works annually on the average (100 days).[1]

In computing the days used annually, no tractor less than one year old was considered, so that a full years' work for each machine is represented. In figure 5 is shown the number of tractors and the days they were used on the home farm for drawbar and belt work.

[1] See U. S. Department of Agriculture Bulletin 560.

It will be seen that the greatest number of operators used their machines between 21 and 30 days annually, the average number of days used per year for all being 29, for draw-bar work 20, and for belt work 9. Many reports have been published and given wide publicity in regard to men who are said to operate their tractors from 100 to 200 days annually. Considering necessary time out for bad weather, Sundays and holidays, moving, maintenance, repair, and time required by other work, it would seem that these figures are extreme.

The age of the tractor does not seem to influence to a great extent the number of days used annually. The figure is uniform for the machines of one, two, and three years, while it drops off about three days for machines of four years and over. This falling off is explained by the fact that the larger machines are in this class and that they are being used less and less for field work, though the time they are used on belt work remains fairly constant.

DISPLACEMENT OF HORSES.

There seems to be a general impression that the use of the tractor will eliminate a large percentage of the horses kept on the farm. However, this has not proved to be the case up to the present time, except in a few scattering instances. (See Table VI.) Too many are misled by the broad statements that are circulated regarding the importance of the tractor in the matter of horse displacement and lose sight of the major advantage of the tractor, namely, its ability to do heavy work and cover the desired acreage in a shorter time than the same can be done by horses. If this fact were generally realized, many a man who has sold his horses upon purchasing a tractor (or even before, as did two of the men under consideration) would have hesitated to do so until he found out just what it was possible to do on his farm with the tractor and what would remain to be done with horses.

TABLE VI.—*Horses displaced by tractors on farms on which tractors had been used one year or more.*

Number of farms	141
	Average.
Number of horses before buying tractor	9¾
Number after buying tractor	7¼
Number displaced	2½
Acreage per horse before buying tractor	35½
Acreage per horse after	47¾

It should be borne in mind that even the best tractor is not suitable for all the necessary operations on a Corn-Belt farm or on any other type of farm, for that matter. It will therefore be necessary to keep enough horses to carry on the operations that it is not possible to do with the tractor.

The market for horses was relatively weak when this inquiry was made, and consequently many horses have been kept on farms where tractors were owned, which otherwise would have been disposed of. This fact will have a bearing on the number of horses displaced on these farms. Often, when the question of how many horses had been disposed of was asked, the reply was: "I could spare more, but the price is so low that I can not afford to sell them."

A significant feature brought out by the inquiry was the lack of colts on these farms. The production of colts, formerly an important side line, seemed to have been practically abandoned, raising a serious question as to the source of the future supply of horses. The reason for this was twofold, the low price paid for horses and the high price of feed. The average cost of feed for horses on these farms was 39 cents per head per day, or $142.35 per year, a considerable increase over prewar prices. If the same horses were to be kept in town, the cost of the feeding would be around 55 cents per day, or $200 per year, the difference being due to the pasturage and cheap feed on the farm which it is not possible to obtain in town. With this high price of feed per year, it will be seen that horses are kept at a loss unless they are doing some productive work a large share of the time. The cost of feeding a horse seems out of proportion to his value, as the average price of the horses displaced on all of the farms was but $161, which figure can also be assumed as the average value of those that were retained, as it was not the poorest horses which were sold, but those of about average quality.

On the farms which had had tractors in operation for one year or more (average acreage 346½) the number of horses displaced averaged 2½. (See table VII.) The acreage per horse before and after was 35.5 and 47.8 acres, respectively, an increase of 12.3 acres per horse. It should be remembered that there was an average increase of 22 acres in the size of the farms after the purchase of tractors.

The number of tillable acres per horse, both before and after the purchase of the tractor, increased from the smaller to the large farms. The increase in percentage of acres per horse, however, is considerably larger for the smaller farms than for the largest group where the number of acres per horse is greatest. The former were keeping more horses than were necessary, while the latter had nearly the minimum number required for their needs before buying a tractor.

TABLE VII.—*Tillable acres per horse before and after the purchase of the tractor and the percentage of increase in each case.*

Size of farm.	Number of farms.	Tillable acres per horse before purchase of tractor.	Tillable acres per horse after purchase of tractor.	Per cent of increase in tillable acres per horse after purchase of tractor.
Under 141 acres	10	18.8	31.5	68
141 to 220 acres	36	22.6	31.4	39
221 to 300 acres	35	23.7	32.3	41
301 to 380 acres	16	23.6	37.4	58
381 to 540 acres	18	23.9	42.3	77
541 to 700 acres	16	31.2	44.1	44
701 and over acres	10	42.2	50.0	19
All farms	141	26.5	38.5	45

The size of the tractor has no uniform bearing on the number of horses displaced and, therefore, can not be used as an index of possible horse displacement when purchasing a machine. The tractor most suitable to the particular needs of the farm should be considered and not its advertised rate of horse displacement.

At the present stage of development the age of the tractor has a very definite bearing on the rate of horse displacement. Though there is a tendency on the part of some owners at first to sell more horses than they should, with the result that it is necessary to rebuy, these men are greatly outnumbered by the more careful operators who are slow to dispose of their horses until they are sure of what can be done with the new outfit. Usually the original purpose in buying a tractor is to do the heavy work, such as plowing, but other uses are soon found as the operator becomes more accustomed to its use and operation.

Reference has been made to the fact that enough horses will have to be kept on the farm to carry on the operations for which it is not practicable to use the tractor. An exception might, however, be noted where it would be cheaper to hire an extra horse or two for a short period to carry the work on rather than keep them at a big expense throughout the year for the short period when needed. It was found that 22 men did just this thing, finding it a great deal cheaper to hire than own. This practice was highly recommended by some, as it saved a team and the necessary cost connected therewith, including investment, harness, feed, and care. Help being scarce, many said it was their only way of obtaining an extra man when needed. Most men who team for hire will not hire out their teams alone. It was the general opinion that a man and team could be hired relatively cheaper than a man alone, and this opinion is borne out by the prices paid by the majority of men who hired, which was but $5 to $6 per

day for one man and a team for cultivating corn, haying, or harvesting. Even paying more for a man and team is certainly cheaper than carrying over an extra team for these operations, providing, of course, that it is possible to hire the labor in the particular community.

EFFECT OF CORN ON THE DISPLACEMENT OF HORSE LABOR.

On 116 farms, each containing 20 or more acres of corn, it was found that 29 were operated with four horses, the acreages in corn ranging from 20 to 119 acres; 26 by six horses, corn acreage 40 to 199; and 15 by eight horses with corn acreages of 40 to 199. All other groups contained fewer than ten farms. Only four farms were operated with two horses, with corn acreages ranging from 20 to 59. In all, 23 farms were operated with odd numbers of horses. The average acreage of corn per horse for this group was 14.

Of 138 farms on which corn occupies a greater acreage than any other crop, 59 had ten acres of corn or under per horse; 44 had 11 to 15 acres; 26 had 16 to 20 acres; and 9 had 20 acres and over. The tendency is strongly toward a smaller number of acres per horse than 20, the number usually figured on. When these same farms are arranged according to the per cent of tillable acres in corn, it is found that the number of tilled acres per horse decreases as the area in corn increases, with but one exception. In other words, the greater the area in corn the fewer horses displaced. This can be attributed to no other reason than that it is necessary to keep enough horses to cultivate corn and do other necessary horse work at corn cultivating time. Until corn is cultivated with a motor cultivator, of which there are several now on the market, it will be necessary to keep these horses, as the ordinary tractor is not suitable for this operation. Many of the farmers interviewed said that if it were not for corn cultivating, more horses could be displaced.

It would seem, therefore, that after eliminating horse labor to a large extent from spring work, the next problem would be to do the same for cultivating by using two-row machines or motor cultivators. At any rate it is clear that, in determining the number of horses that will be displaced by the tractor, it will be necessary first to determine the number of horses required to cultivate the usual corn acreage and carry on the other necessary work coming in these periods.

INFLUENCE OF THE TRACTOR ON DISTRIBUTION OF HORSE LABOR.

Farms of the Corn Belt should offer almost ideal conditions for using the tractor. Not only is the topography generally favorable, but the operations for which the tractor is best fitted (those which require the greatest amount of horse labor in the shortest possible

time, namely, the preparation of ground for spring crops) are the operations which require the greatest amount of drawbar work on a Corn-Belt farm (fig. 6). It has been shown that it is necessary for a horse-operated farm to carry enough horses throughout the year to carry on the work during the spring rush.

FIG. 6.—One man, with tractor and two-bottom plow (upper) doing the work of two men and two 2-horse teams with two 1-bottom sulky plows (lower).

In figure 7, in the left-hand column, is shown the distribution of horse labor throughout the year on an ordinary Corn-Belt farm of 200 acres.[1]

[1] Thanks are due to Mr. J. S. Ball of the Office of Farm Management, U. S. Department of Agriculture, for the data used in compiling the left-hand column of figure 7

It will be seen that the greatest amount of horse labor comes late in April and consists mainly of plowing for corn and the various

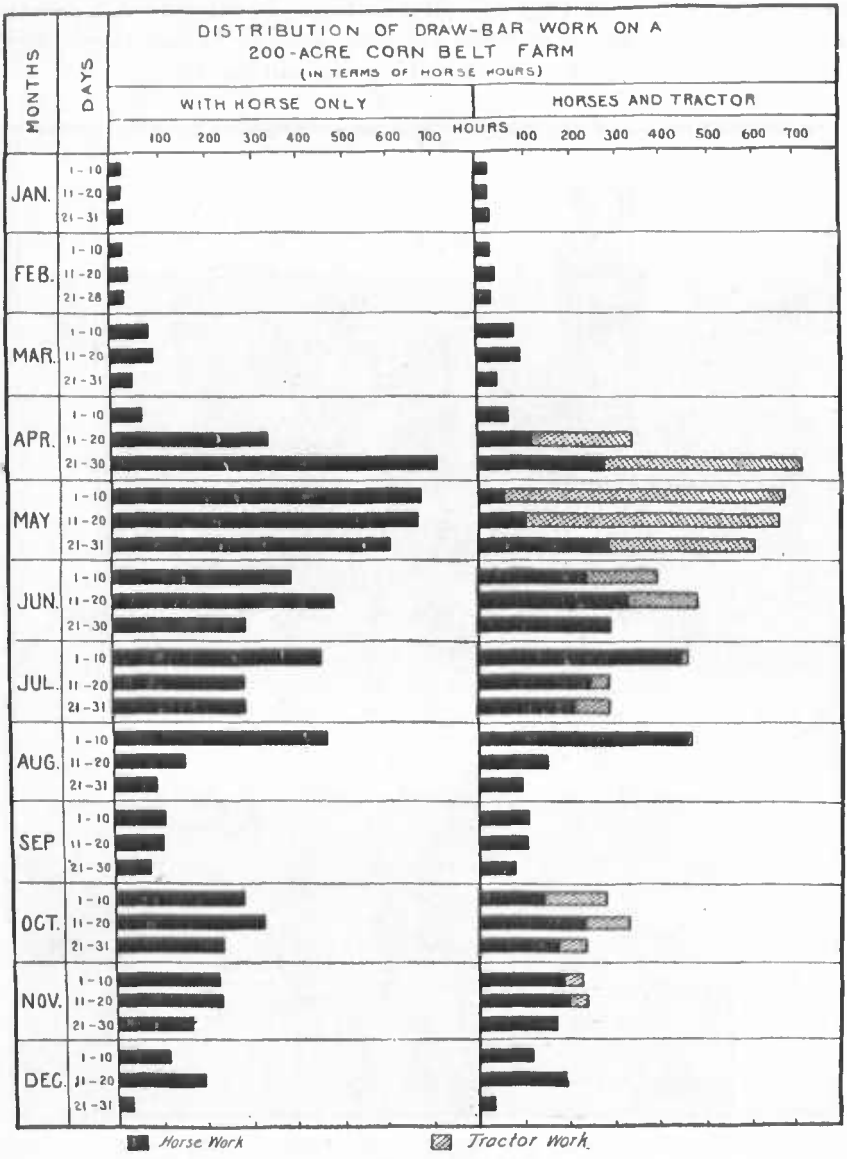

FIG. 7.—Distribution of drawbar work on a 200-acre Corn-Belt farm. Left: Horse labor for year by 10-day periods. Right: Same for horses and tractor, shaded portion of bars representing horse labor eliminated by maximum substitution of tractor for horses.

operations involved in getting the oats crop sown. The next three large 10-day periods, covering the month of May, are in the main devoted to the preparing of corn ground and corn planting. Corn

cultivating is spread over the period from June 1 to August 1, and at no time does it approach in intensity the work required for preparation of the soil.

The work required on this farm during the heavy 10-day period in April amounted to 711 horse-hours. With two days out of the period for Sunday and inclement weather, there remained eight working days of 10 hours each. With nine horses, the number on this farm, each working every day, it would have been possible to put in a total of 720 horse-hours in the eight days. This would necessarily mean that no time be lost, as the margin is small. In the spring, during this rush period, it is usually the custom to put in a greater number of hours per day in the field than 10, so that no time be lost in getting the ground in shape for crops.

The month of May requires nearly as great an amount of horse labor for each 10-day period as is required in April, for there will be days when no field work can be done. During this 40-day stretch of heavy horse labor the nine horses on this farm are seldom idle. It would not be necessary, however, to use this number for corn plowing or for any other operation during the remainder of the year, as six horses are capable of doing any work necessary after the crops are in. Immediately after the corn is planted the horses can be worked alternately on the various operations, which would give each the usual needed rest after the heavy spring work.

The greater part of the work in the 10-day periods of June 11–20 and July 1–10 is corn cultivating, and as there is little competing work during that time there is no rush of work to be done in a short period. Thrashing takes most of the time during the 10-day period of August 1–10. This includes return labor to neighbors who help in thrashing on the home farm. After the August period the work for nine horses is very light, and they are consequently idle a great share of the time.

In the right-hand column of figure 7 is shown the estimated maximum horse labor which a tractor could replace on this same farm. With the tractor doing all the work for which it is suited, a considerable amount of horse labor would be eliminated. The black area in this column shows the number of hours labor that it would still be necessary to do with the remaining horses, while the shaded area shows the number of horse hours which the tractor would eliminate while doing the same work in considerably less time.

If a tractor were used, the peak load for horse labor would come during the first 10 days in August. The larger part of this work is thrashing and is all done in two days' time. It is not usually necessary, however, to have horses enough to carry the work over this period, since extra teams are ordinarily furnished by neighbors in the customary exchange of labor in thrashing. The number of horses

necessary to keep would then depend upon other factors, and it is found that the largest amount of horse labor absolutely required would be that demanded during the periods of June 11–20 and July 1–10. Most of this work is corn cultivation, and to be perfectly safe six horses would be necessary to do the work, as there are 108 acres of corn on the farm. Thus three horses safely could be disposed of and still leave enough to do all the necessary work.

A still further indication of what the effect of the tractor on this farm would be is given by the following figures: The total number of days which the nine horses worked on this 200-acre farm in one year was 850, or an average per horse of 94½ days per year, which is close to the 100-day average usually given. With the addition of a tractor doing the work for which it is suitable 321 days of horse labor would be eliminated, which would then leave 529 days of labor still requiring the work of horses to perform, while the tractor does the remainder. If three horses are disposed of there would be left 88 days of labor per year for each of the remaining six horses, or 6½ days less labor per horse than before.

Of the entire amount of tractive work done during the year, the tractor would do approximately 38 per cent and the horses the remaining 62 per cent. It must be understood that the work which the tractor is here represented as doing is the maximum amount that possibly could be done on the drawbar on this farm, and on few farms, if any, would the full amount here shown be done. Within reasonable limits the difference between the possible maximum and the actual amount of work performed by the tractor could well be taken care of by the six horses, which would act as an auxiliary source of power at all times, and be able to help out in most of the emergencies that might arise. Further, there would be work for the tractor on the belt, but this is not ordinarily a competing-horse operation, so the number of days' belt work is not considered.

Considering the acreage covered and the time required by the tractor on various major operations with reference to the work formerly done by horses, it is found that a 3-bottom tractor would, in the same time, all conditions being equal, do the work of 8½ horses. However, it should not be taken that the tractor will displace this number of horses. At this rate the plowing, disking, harrowing, and harvesting which would take the entire nine horses about 36 days to do could be done with the tractor alone in about 38 days of 10 hours each. Thus it will be readily seen how with the tractor it is possible to increase the size of the farm without hiring more man labor, as many operators do; for, as stated before, one man is able to handle more acres with a tractor than with horses in a given time.

Attention is now directed to the results which have been obtained on the entire group of farms as compared with those shown for one

farm in figure 7. It should be remembered that in the case of the one farm cited, the principal crops were corn, oats, and hay, while in the large group the averages reflect the influences of various cropping systems. The number of days of horse labor required per year for all operations since the advent of the tractor was ascertained for each of the farms, so that a comparison could be made of the days of tractor work and of horse work.

The number of days of horse labor expended annually on the 141 farms, averaging 346 acres, upon which a tractor had been in operation one year or more, was 566, or an average per horse of 78 days per year. This figure as compared to the 94½ days on the 200-acre farm is low, and indicates that the horses were idle too much of the time. This bears out the surmise that more horses might have been sold from these farms had the market price been high enough. If now the average number of horses on these farms were reduced by one, the number of day's work for the remaining horses would then be 90½ per year, which would be near what it should be and still leave a margin of safety, for it is considered that, on the average, a horse works approximately 100 days annually in the Corn Belt.[1]

The drawbar work that the tractor is doing, expressed in terms of horse-days, amounts to but 172¾ days annually, which would indicate that many machines are falling far below the maximum amount of work a tractor can do, in view of the possible elimination of horse labor on the above-cited 200-acre farm (321 horse-days). This is accounted for by the fact that there are many old machines which are too heavy to work on preparing ground and related operations, and which are used for plowing only. The newer and lighter machines show a considerable higher average number of days' drawbar work per year than the general average.

The average share of the drawbar work that the tractor does on these farms is approximately 25 per cent, which leaves 75 per cent for the horses to do as compared to 62 per cent for the horses and 38 per cent maximum for the tractor as estimated for the 200-acre farm above cited.

USE OF HORSES WHILE TRACTOR IS IN OPERATION.

With the high price of feed (see p. 18) it is now more important than ever before to obtain the maximum amount of work from the horses which remain on the farm after the purchase of the tractor. Of course, there is only a certain amount of productive work to be done on any farm without a change of organization, and when this is completed there is nothing left for the horses but to stand idle.

[1] U. S. Department of Agriculture Bulletin 560.

During the seasons when the greatest amount of horse labor is required, it is not a very difficult task to find enough profitable work to keep the work animals busy, but the problem of keeping the horses profitably busy when the tractor is in operation is one that will tax most farmers to solve. If the farm is being operated by the farmer alone, there will be no solution for the problem of idle horses unless he has boys large enough to handle a team for minor operations. If a hired man is employed, the problem will be nearer to solution. As stated before, the tractor eliminates hired help to a certain extent, as well as horses, both depending on size of the farm.

To ascertain what operators are doing with their horses while their tractor is in operation the question was asked of each, "What use do you make of your horses while you are operating your tractor?" The answers received to this question are summarized below, and no doubt they will be of interest to other operators who find trouble in keeping their horses busy at this particular time.

From 177 reports it was found that only 16 operators allowed their horses to stand idle while the tractor was being used for drawbar work, 85 reported that their horses were idle part of the time, and 76 said their horses were fully occupied. Of the 85 reporting their horses idle part of the time, 30 reported that they did some hauling on the road or used them on the manure spreader, but most of the work reported consisted of plowing, disking, and harrowing. In the cases of the 76 reporting their horses fully occupied, plowing, disking, and harrowing constituted the major part of the work done.

CONCLUSION.

It will be evident from the foregoing that the most important effect of the introduction of the tractor on the horse-labor schedule is the shifting of the peak load of horse labor from the spring season to the corn cultivating season. It has already been pointed out that the work of thrashing, which appears as the peak in figure 7, is not so heavy as it looks, since it is done by the usual exchange of teams. The real peak load that remains after the tractor has assumed the burden of the preparation of the land falls in the period of June 11 to July 29, when corn cultivation is at its height. Certain other farm operations require drawbar power at the same time, some of which can not be done by the tractor. Hence, the following general rule may be laid down with regard to the number of horses that it is necessary to retain on the farm after buying a tractor:

Keep enough horses to cultivate corn and do other necessary work which must be done at the same time, but which the tractor can not do.

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